BRC Science Highlight
March 2022

Implementing Spatio-Temporal 3D-Convolution Neural Networks and UAV Time Series Imagery to Better Predict Lodging Damage in Sorghum

Background/objective

The development of analytical tools that provide precise and timely evaluation of lodging would allow breeders to screen larger populations of biomass-type *Sorghum bicolor* (L.) *Moench* lines to select germplasm that suffers less from lodging and accelerate crop improvement. While CNNs have proved to be a powerful image analysis technique, most studies have only exploited the spatial dimension of the data. This work also provides a case study on examining the effect of time, as an additional feature, on lodging detection and severity predictions.

Approach

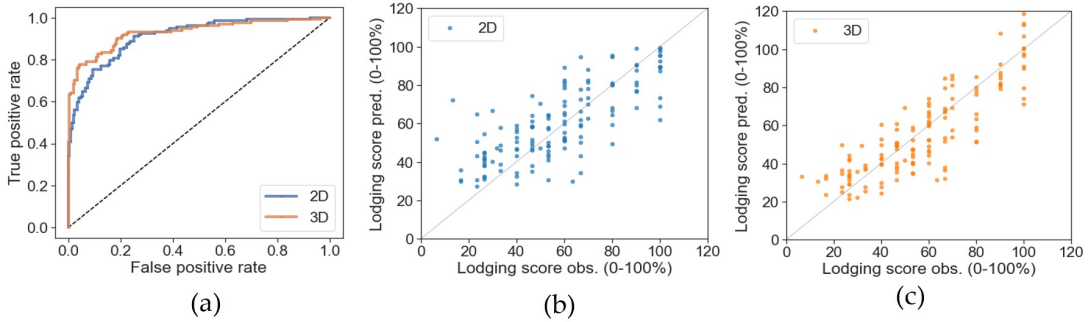
- Multispectral and geometric time series imagery was collected by UAV on 11 dates, along with ground-truth data, in a field trial of 866 genetically diverse biomass sorghum accessions. We compared the performance of CNNs that analyzed data from single dates (2D-CNN) versus multiple dates (3D-CNN) to determine lodging detection and severity.

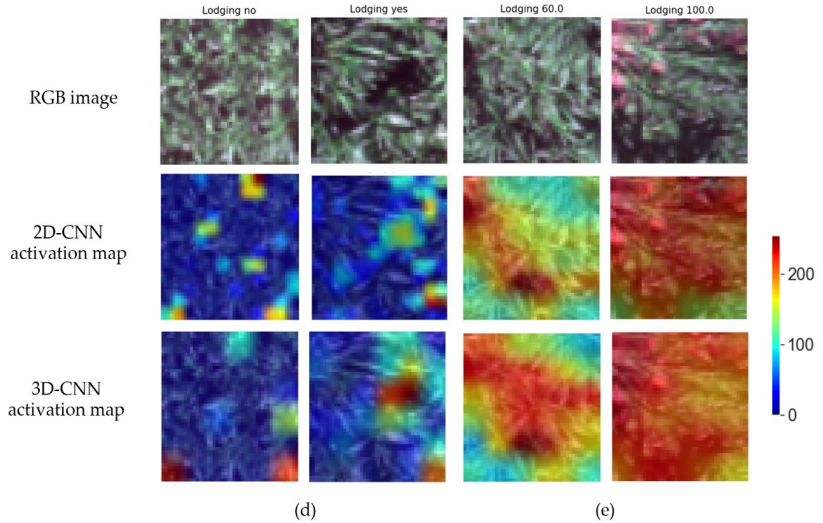
Results

- The accuracy of lodging detection (presence/absence) was only slightly improved with 3D-CNN (88%) versus 2D-CNN analysis (85%). But, leveraging time-series data and 3D-CNN to estimate quantitative variation in lodging severity (a harder but more useful trait to assess) produced significant performance gains over the traditional 2D-CNN approach.

Significance

- The implementation of 3D-CNN architecture improved the rapid prediction of lodging, which is an important and difficult phenomenon to assess in bioenergy feedstocks such as biomass sorghum.
- This demonstrates that spatio-temporal CNN architectures based on UAV time series imagery have significant potential to enhance field plant phenotyping.





Evaluation of best 2D and 3D-models on lodging detection via ROC curves (a), and best 2D (b) and 3D (c) for lodging severity prediction. Activation maps visualization using last convolution layer of each CNN architecture for lodging detection (d), and severity (e) predictions.

Varela et al., Feb. 4, 2022. "Implementing Spatio-Temporal 3D-Convolution Neural Networks and UAV Time Series Imagery to Better Predict Lodging Damage in Sorghum." Remote Sensing 14(3): 733. DOI: 10.3390/rs14030733.

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